2mip

E74-10553
CR-138443

ERTS DATA USER TYPE-1 PROGRESS REPORT FOR MARCH/APRIL 1974

Project Title/Objective: Relevance of ERTS to the State of Ohio

Proposal Number: MMC No. 87

Contract Number: NAS5-21782

BCL Subcontract Number: 72-17/G-1793

Principal Investigator: Dr. David C. Sweet

I. DATA COLLECTION

ERTS-1 data received from NASA during this reporting period are summarized in Table 1. In addition to the imagery described in the Table, computer compatible tape data have also been received for most of these same scenes. Figure 1 illustrates the present status of all usable repetitive ERTS imagery of the various portions of Ohio. Many of the multispectral color composites that have been requested for most of the usable ERTS scenes of Ohio have also been recieved.

No aircraft or ground truth study site data collection activities were conducted during this reporting period.

II. DATA ANALYSIS

No major analytical activities were conducted during this reporting period. However, program activities focused on the preparation of various demonstration and display products illustrating the potential usefulness of ERTS data to multidisciplinary and multiagency interests and activities in Ohio. These items were prepared primarily for use during the Ohio ERTS/Skylab Data User Workshop and for subsequent publication in a paper presented at the Ninth International Symposium on Remote Sensing of Environment on April 19, 1974 in Ann Arbor, Michigan, by State of Ohio and Battelle personnel. A copy of this paper entitled "Multidisciplinary Applications of ERTS and Skylab Data in Ohio" has been included as an attachment to this report.

TABLE 1. COVERAGE AND QUALITY OF ERTS-1 DATA OVER OHIO RECEIVED DURING THIS REPORTING PERIOD

Date	Time		Quality Comments*
		TRACE 1	
2/12/74	15315	Eastern Ohio and Western Pa.	Fair
2/12/74	15322	SE Ohio and West Virginia	Very Good
3/20/74	15305	NE Ohio and Western Lake Erie	Excellent
3/20/74	15312	Eastern Ohio and Western Pa.	Excellent
3/20/74	15314	SE Ohio and West Virginia	Fair
		TRACE 2	
2/13/74	15371	NE Ohio, Lake Erie, and Canada	Very Good
2/13/74	15374	Columbus and Eastern Ohio	Good
2/13/74	15380	SE Ohio	Poor
2/13/74	15383	SE Ohio and Kentucky	Fair
3/3/74	15381	SE Ohio	Fair
		TRACE 3	
2/14/74	15430	NW Ohio and Lake Erie	Very Good
2/14/74	15432	Columbus and Western Ohio	Fair
2/14/74	15435	SW Ohio, Indiana, and Kentucky	Poor
3/4/74	15433	SW Ohio, Indiana, and Kentucky	Fair
		TRACE 4	
12/5/73	15501	NW Ohio, Michigan, and Indiana	Very Poor
12/5/73	15510	Western Ohio and Eastern Indiana	Very Poor
12/5/73	15512	SW Ohio, Indiana, and Kentucky	Very Poor
2/15/74	15484	NW Ohio, Michigan, and Indiana	Excellent
2/15/74	15490	Western Ohio and Eastern Indiana	Excellent
2/15/74	15493	SW Ohio, Indiana, and Kentucky	Excellent
3/5/74	15482	NW Ohio, Michigan, and Indiana	Very Good
3/5/74	15485	Western Ohio and Eastern Indiana	Fair
3/5/74	15491	SW Ohio, Indiana, and Kentucky	Fair

*Quality relates to general cloud cover condition over area covered by satellite photography.

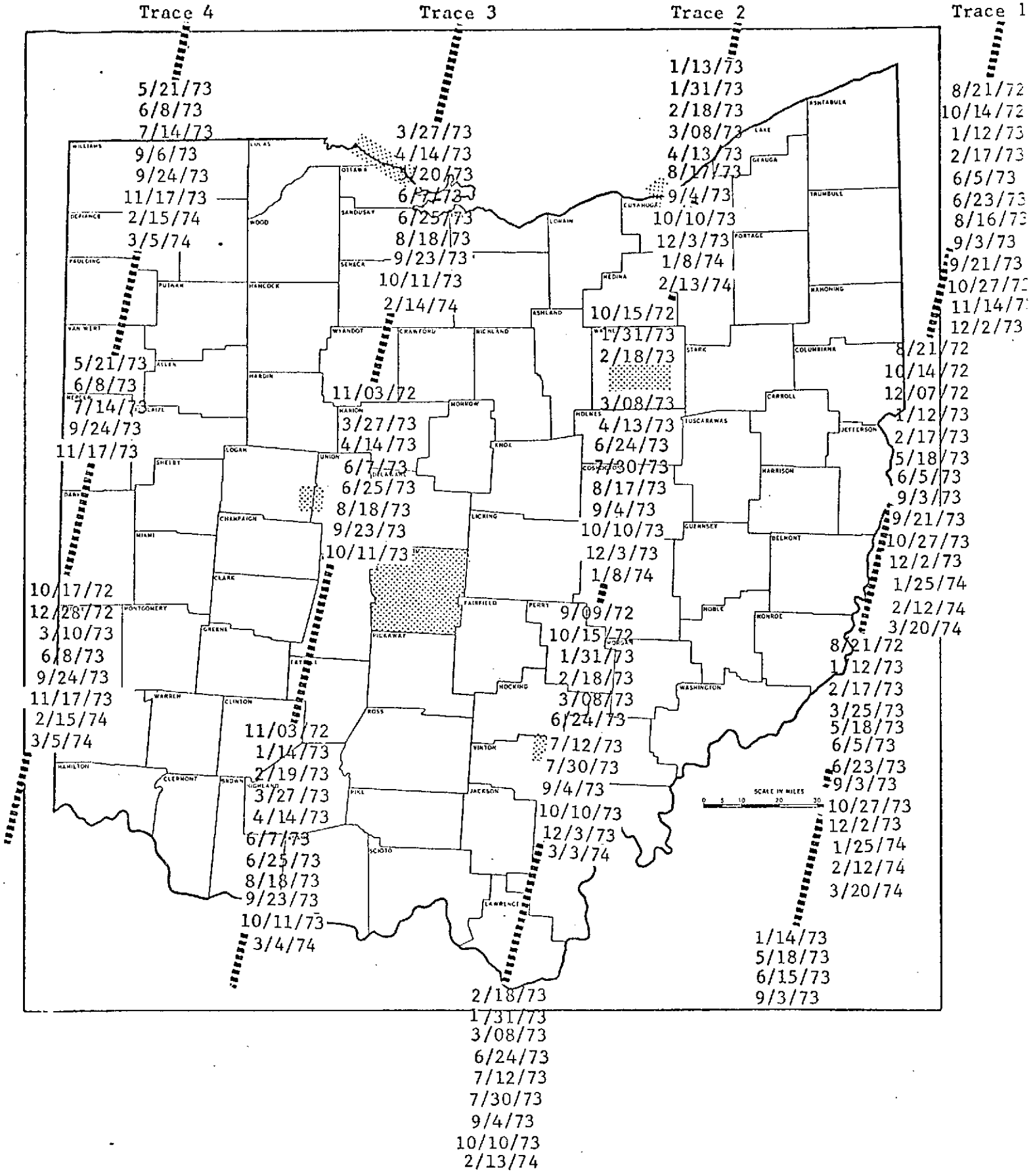


Fig. 1. Status of Usable Repetitive ERTS Imagery for Ohio

III. DCS/DCP EFFORT

As stated in the previous progress reports, use of the Ohio-ERTS DCP has been discontinued temporarily because of some unknown malfunction. On April 1, 1974, the Data Collection Platform was again returned to NASA's Wallops Island facility for repair and has not as yet been returned.

Also, during this reporting period a response was prepared to a questionnaire survey being conducted by Mathematica, Inc. as part of a NASA funded program to assess the potential for satellite data collection and relay services.

IV. DATA UTILITY ASSESSMENT

During this reporting period continuing attention was given to testing the usefulness of ERTS imagery to individual programs and interests within various agencies. Another fifty visitors toured the Remote Sensing Applications Laboratory during March and April where Battelle and State personnel jointly analyzed ERTS data in regard to a variety of State data needs. Other visitors of Battelle's Remote Sensing Applications Laboratory during this reporting period included NASA officials, foreign visitors, students, and numerous participants from the Battelle Land Use Conference held on March 26-27, 1974.

The major program activities conducted during this reporting period was the Ohio ERTS/Skylab Data User Workshop held on March 4-5, 1974 in which approximately 100 land use, resource, and environmental planners from all sections and levels of government and private sector participated. The principal purpose of this two-day workshop was to present the significant results of the Ohio ERTS and Skylab programs to date and to provide an assessment of the utility of satellite survey data to problem areas at the local, regional, and state levels in Ohio. While serving basically as another user awareness activity, the workshop was also tailored to solicit user views as to the potential usefulness and/or limitations of data and data products obtainable from satellite surveys.

The State is now in the assessment phase of the Ohio ERTS-1 program. The assessment of the utility/relevance of ERTS data is being based on a combination of 1) user attitudes expressed while directly participating in laboratory problem-solving exercises, 2) user evaluation of application-oriented ERTS demonstration products generated during the course of the program, and 3) user views expressed directly or recorded on questionnaires during the Ohio ERTS/Skylab Data User Workshop. The final evaluations and recommendations derived from the program will be presented the final Type III report.

V. SIGNIFICANT RESULTS

There were no significant program results this reporting period.

VI. MISCELLANEOUS

During this reporting period cloud free ERTS-1 MSS Band 5 70-mm negatives were provided to NASA Lewis Research Center for constructing a photo mosaic of the entire State of Ohio for education/public relation purposes.

In a March 13, 1974 letter to Mr. Douglas Frye, NASA/GSFC Contract Specialist, a request to extend the existing ERTS-1 data standing order after the announced April 4, 1974 expiration date was sought. To date no reply has been received concerning this ERTS-1 data extension request. The request was made in order to maintain the continuity in the satellite data base on Ohio, and since all ERTS-1 data received to date as well as future data acquired during the operational life of ERTS-1 will be a vital element in the proposed Ohio follow-on ERTS-B program.

MULTIDISCIPLINARY APPLICATIONS OF ERTS AND SKYLAB DATA IN OHIO

D. C. Sweet[1], P. G. Pincura[1],
C. J. Meier[2], G. B. Garrett[3], L. O. Herd[4],
J. M. Dowdy[5], D. M. Anderson[6]

State Government of Ohio

G. E. Wukelic, J. G. Stephan,
H. E. Smail, and T. F. Ebbert

Battelle, Columbus Laboratories
Columbus, Ohio

ABSTRACT

Experimental studies of ERTS-1 and Skylab earth resources data, in combination with correlative aircraft and on-site data, for environmental quality, land use, and resource management applications in Ohio show several areas of operational promise. Prime data use candidates demonstrated to date include definition and enforcement of surface mining (all minerals) legislation; Lake Erie modeling/management; land use classification and mapping studies at state, regional and localized levels; and resources' inventories particularly of forested areas on both regional (multicounty) and localized scales.

Clearly, NASA satellites can provide the data necessary for comprehensive and routine inventorying and mapping of Ohio's natural and cultural features; for the systematic detection of environmental hazards; and for new interdisciplinary legislative, planning, policy formulating, and management concepts that can form the basis for effective and cooperative government decision making in Ohio. However, to be of maximum benefit will require some spectral, spatial, and temporal improvements in future satellite capabilities and significant improvements in procedures to provide more useful and timely data products to end users.

I. INTRODUCTION

Since July 1972, the State Government of Ohio in concert with Battelle's Columbus Laboratories, and with funding assistance from NASA, has been involved in a multidisciplinaryand multiagency study of the statewide utility of ERTS-1 and Skylab EREP (Earth Resources Experiment Package) data. Specifically, under study are the environmental quality, land use, and resource management implications with six state agencies directly participating. The quantity and quality of satellite data acquired by NASA, the extent of statewide cooperation, and

(1) Department of Economic and Community Development
(2) Department of Natural Resources
(3) Ohio Environmental Protection Agency
(4) Department of Transportation
(5) The Ohio State University
(6) Ohio Biological Survey

Paper Presented at the Ninth International Symposium on Remote Sensing of Environment
Ann Arbor, Michigan, March 15-19, 1974.

the practical application possibilities identified, have all exceeded initial expectations. Because of the broad scope of discipline applications under study, and the fact that user evaluation interests extend all the way from simple, one-time, very localized problem-solving data need situations to very sophisticated and comprehensive state policy formulation and enforcement activities requiring real-time data capabilities, suggest that Ohio user program experience (both positive and negative) should be of interest to a broad spectrum of potential satellite data user communities. This is particularly so considering the similarities existing in current priority problems, legislation trends, technical capabilities, resources allocations, and investment limitations not only among states, but in many cases among smaller, developed countries as well.

This paper summarizes the status of efforts involving: 1) application analyses and demonstrations, and 2) user awareness and utility assessment. The emphasis is placed on describing data analysis techniques and satellite data applications results considered at present to have the greatest potential for benefiting the State on an operational basis. Current State user views as to the compatibility of data being provided and routine data required, along with suggestions for maximizing operational benefits at the state, regional, and local levels are also offered. In several cases, more detailed information on user needs, activities in progress, and experimental results is contained in reports presented at previous ERTS-related symposia[1-3].*

2. APPLICATION ANALYSES AND DEMONSTRATIONS

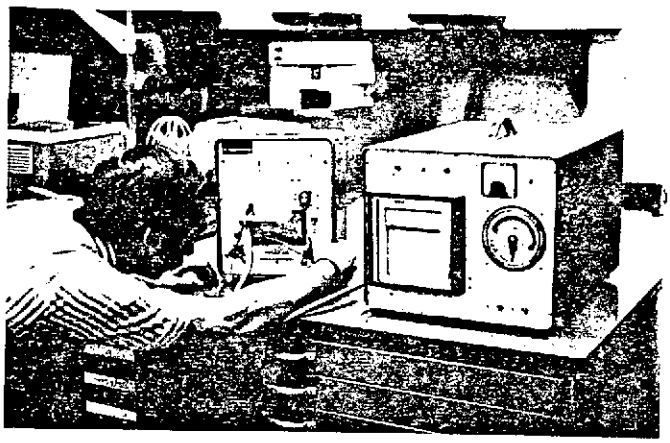
Acquisition and analyses of correlative satellite, aircraft, and on-site data using state-of-the-art data collection equipment and manual and machine-aided analysis techniques have represented the major program efforts to date.

2.1 DATA COLLECTION AND ANALYSIS TECHNIQUES

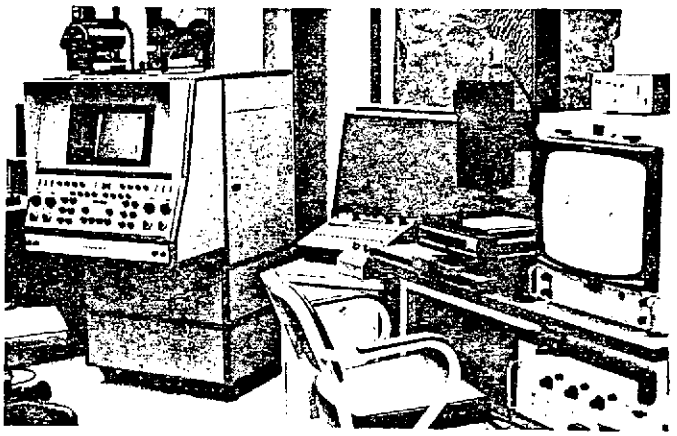
NASA ERTS multispectral data in 70 mm, 24 x 24 cm imagery and digitized tape formats have been received periodically by the State of Ohio beginning August 21, 1972. Consecutive, usable data for all four passes which cover Ohio every 18 days have never been received, however all areas of Ohio have been recorded by the satellite at least once every season. To verify the analysis performed on imaged and digitized ERTS data, aircraft underflight and radiometric ground observations have also been obtained. Aircraft data have been collected by the Department of Transportation Aerial Engineering Section at scales of 1:24,000. A second opening in the fuselage of the Beechcraft aircraft provided for the installation of a multispectral camera arrangement of four Hasselblad EL 500 cameras. Ground observations are made with an ISCO radiometer and recorder which has a spectral range of 0.35 μ to 1.55 μ shown in Figure 1a. The data have been primarily collected in five Ohio study sites selected to represent discipline areas of principal interest. However, additional data have also been obtained for other areas of special interest to Ohio planners. For demonstration purposes, water quality and meteorological data are collected and relayed to ERTS-1 by a Data Collection Platform on station at a lake at the Battelle West Jefferson Nuclear Facility. More recently ERTS data are being supplemented by multispectral data acquired for selected Ohio areas during the manned Skylab missions. NASA is providing aircraft underflight data in support of Skylab data analysis efforts.

---

* Superscripts denote references cited at the end of this paper.



a. ISCO Radiometer and Recorder.



b. Color Additive Viewer and Density Slicing and Color Encoding Analysis System.

FIGURE 1. DATA COLLECTION AND ANALYSIS EQUIPMENT USED BY STATE OF OHIO AND BATTELLE IN ERTS AND SKYLAB PROGRAMS

Most analytical tasks are being performed in the Battelle Remote Sensing Applications Laboratory shown in Figure 1b. The facility was designed so as to provide visiting user personnel with as many interpretation and analysis options as possible to determine in what format and to what scale ERTS and Skylab data may be useful to their specific needs. Light tables, rearview projectors and a Richardson Multiple Interpretation Module are used for standard analyses. A Spectral Data Corporation multispectral viewer with 70 mm and 24 x 24 cm film drives provide for the simultaneous analysis of up to four ERTS or Skylab channels. Each channel has three color filters and 20 neutral density filters in steps from 0-100% transmissivity. A Spatial Data density slicing color viewer allows for the discrimination of densities as small as .01D, and their display in up to 32 colors. A built-in electronic planimeter measures areas of equal densities with 99.5% accuracy. The television system has been modified to provide for magnifications up to 80X. Magnification of ERTS/Skylab imagery (scales of 1:24,000 is readily achieved; an XY comparator movement provides for locating image points especially at high-image magnification. A half-silver mirror system and a dual TV monitor setup as shown in Figure 2 provide for the superimposition of cartographic and remotely sensed data at a common scale. Map scales commonly used are 1:500,000, 1:250,000 and 1:24,000. Figure 3 shows a second analysis mode in which the dual television system links the multispectral and density slicing viewers, with the result that density slicing may be performed on one to four data channels. A rearview projection system built into one side of the laboratory and consisting of three 35 mm and two 70 mm projectors displays to the analyst radiometric, ground truth, underflight and previously analyzed ERTS and Skylab data.

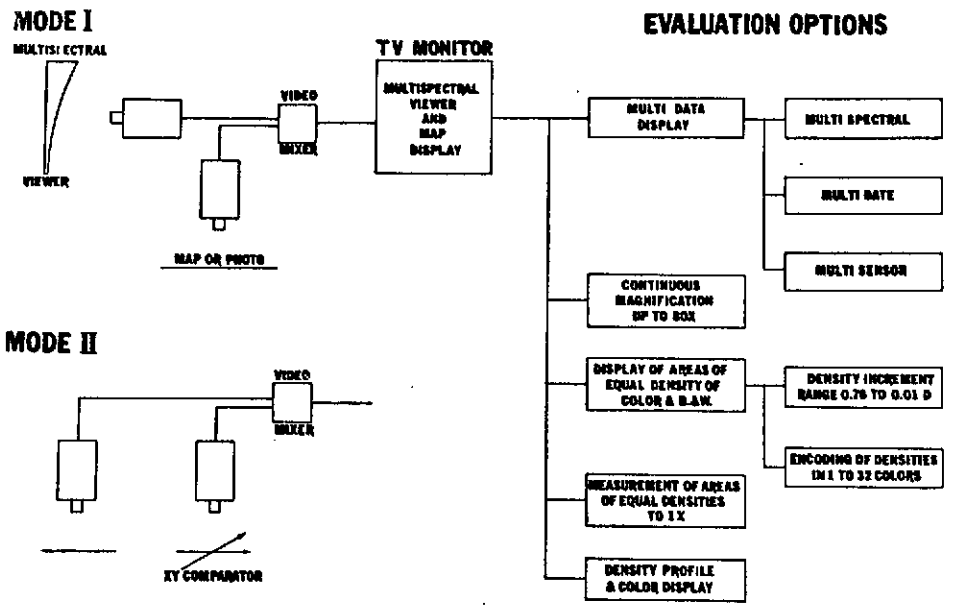


FIGURE 2. OHIO ERTS AND SKYLAB IMAGERY ANALYSIS AND EVALUATION OPTIONS

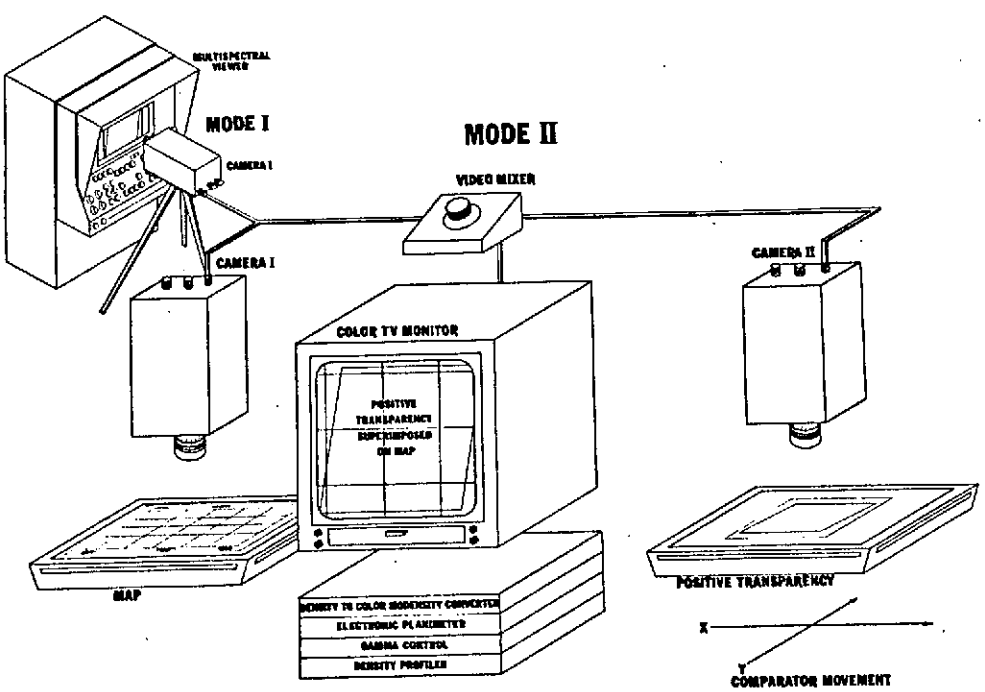


FIGURE 3. ANALYTICAL TECHNIQUE FOR COMBINING MULTISPECTRAL AND DENSITY SLICING VIEWERS

A Control Data 6400 computer is used for the processing of digital ERTS tapes. However the use of computerized techniques has been limited to land use analysis in the Franklin County area to scales up to 1:30,000. This technique will have to be expanded to prepare for routine state use of such data. Up to now the emphasis has been on the analysis of spectral information using opto-electro-mechanical devices. This procedure sacrifices some resolution but permits more effective initial interaction between potential users and satellite data interpretations. The most common requirement has been for updating map data ranging from scales of 1:24,000 to 1:500,000. Areas to be analyzed ranged from four hectares (10 acres) to multiple ERTS frames covering more than 68,000 km^2.

2.2 DATA APPLICATIONS

The overall scope and status of analytical efforts to evaluate ERTS and Skylab data utility in Ohio are shown in Table I. The table identifies the specific data uses under consideration, the current evaluation status, and the analysis techniques (i.e., imagery or digital) employed in the three discipline areas of interest: 1) environmental quality, 2) land use and 3) resource management.

2.2.1 ENVIRONMENTAL QUALITY

The recent establishment of the Ohio Environmental Protection Agency (OEPA), the increasing seriousness of the Department of Natural Resources' efforts to ensure the wise use of the State's natural resources, and the equally important but difficult mission of the Department of Economic and Community Development of providing for balanced development in Ohio reflect the demand for improved and current statewide air, water, and land quality data for cooperative multiagency utilization.

2.2.1.1 AIR QUALITY

Since major smoke plumes such as from coal-fueled power plants and steel mills are readily discernible on repetitive ERTS scenes(1), the Ohio Environmental Protection Agency plans to use ERTS data showing the location, movement, and confluence of smoke plumes to test computerized air motion models being developed for use in major statewide air pollution control practices. Also, preliminary analyses of ERTS and Skylab imagery have shown that large scale vegetative damage caused by toxic air pollutants can be discerned sufficiently to provide gross estimates of the damage.

2.2.1.2 WATER QUALITY

Ohio EPA researchers are enthusiastic about the potential use of satellite photography for Lake Erie water quality management practices. Illustrations of the ability of ERTS to provide an overview of Lake Erie pollution and sedimentation patterns heretofore unavailable are contained in earlier papers(2,3). From a preliminary analysis of repetitive ERTS scenes, OEPA personnel are optimistic that ERTS data can lead to a better understanding of the complex and dynamic characteristics of Lake Erie and thus make more accurate modeling possible. In addition to a more precise definition of nearshore and offshore developments, OEPA personnel are interested in evaluating such specific correlations as: littoral drift/lake dispersions, algae masses, temperature phenomena, and water level. These same parameters are also of concern to the Department of Natural Resources (DNR) for coastal zone management considerations. It also has been demonstrated that

TABLE I. DEMONSTRATED OHIO ERTS/SKYLAB DATA APPLICATIONS

Application Areas Under Evaluation	Data Evaluated	
	ERTS	Skylab
ENVIRONMENTAL QUALITY		
AIR QUALITY		
• Smoke Plume	Imagery	Imagery
• Vegetation Damage	Imagery	Imagery
WATER QUALITY		
• Algae Blooms		
• Circulation Patterns	Imagery	Imagery
• Suspended Sediments	Imagery/Digital	Imagery
LAND QUALITY		
• Sanitary Landfills (Illegal)	Imagery/Negative	
• Scenic Areas/Outdoor Recreation		
• Critical Areas	Imagery	Imagery
• Surface Mining	Imagery/Digital(4)	Imagery
LAND USE		
FEATURE CLASSIFICATION		
• Levels I and II	Imagery/Digital	Imagery
MAPPING		
• State (1:250,000 & Smaller)	Imagery	Imagery
• Regional (~1:125,000)	Imagery/Digital	Imagery
• Local (1:24,000 & Larger)	Imagery/Digital	Imagery
TREND ANALYSIS		
• Developing Areas		
• Transportation	Imagery	Imagery
RESOURCE MANAGEMENT		
AGRICULTURE		
• Crop Identification	Imagery/Negative	
• Soil Identification/Moisture		
• Prime Agr. Land Designation		
• Soil Erosion	Imagery	Imagery
FORESTRY		
• Inventory and Species Classification	Imagery	
FLOOD PLAIN/WETLANDS		
• Mapping and Inventorying	Imagery	Imagery

orbital survey data can be used in water resources and flood inventories, shore-erosion detection, mapping of impounded water bodies in surface-mined areas, and reservoir condition monitoring. Because of the need to detect and monitor thermal pollution, the poor performance of the thermal scanner on Skylab and the decision to exclude a thermal sensor on ERTS B were serious disappointments to participating state user personnel.

2.2.1.3 LAND QUALITY

Surface mining is a major industry in Ohio which has become a prime area of citizen and government concern as environmental and energy issues collide. The seriousness of the problem has been recently quantified in a State study(5) which found over 150,000 hectares (370,000 acres) of strip-mined lands in Ohio requiring some form of reclamation at an estimated cost of 290 million dollars. Because of these findings, anticipated increases in Ohio surface mining activities, and monitoring provisions required by the new, more rigorous Ohio strip mine law enacted in 1972 as well as in the "All Minerals Bill" currently under legislative committee review, satellite survey data application possibilities are timely and relevant to both private and public sector interests.

Correlation analyses of ERTS-1 MSS imagery, aircraft photography, and on-site radiometric (spectral) data of strip mine areas in eastern Ohio have demonstrated that satellite imagery can be utilized to inventory (within the accuracy limitations of scale) the extent of coal strip mining, to assess to a limited degree the conditions of the stripped terrain, and to monitor mining progress provided repetitive imagery is obtained. These ERTS results are described in detail in a report especially prepared to demonstrate the applicability of satellite survey data to surface mining activities of the type practiced in Ohio(6). Similar results based on using ERTS computer compatible tapes have been reported by Pettyjohn, et al.(4).

A one-year comparison study of a major strip mining area located in eastern Ohio was recently undertaken to demonstrate the value of repetitive satellite imagery for monitoring surface mining operations. The study site chosen was a controversial area where two of Ohio's major mining shovels had moved into during January, 1973. The comparison was made between a portion of the MSS Band 5 image of 21 August 72 and 3 September 73. During the one-year period over 400 hectares (1,000 acres) of land were affected as illustrated in Figure 4.

Figure 5 shows the ability of both ERTS and Skylab imagery to reveal reclamation activities as well, although additional effort is necessary to establish the accuracy and extent that reclamation activities can be determined. When enlarged, the Skylab imagery has the capability of providing considerably more information about strip mine surface parameters because of the increased resolution. This is illustrated in Figure 6 where enlarged Skylab S-190 data are compared to aerial photography. The Skylab data clearly reveal the exposed coal seam, vegetation differences, the high wall, the location of the spoil bank, etc.; features not discernible on ERTS-1 imagery.

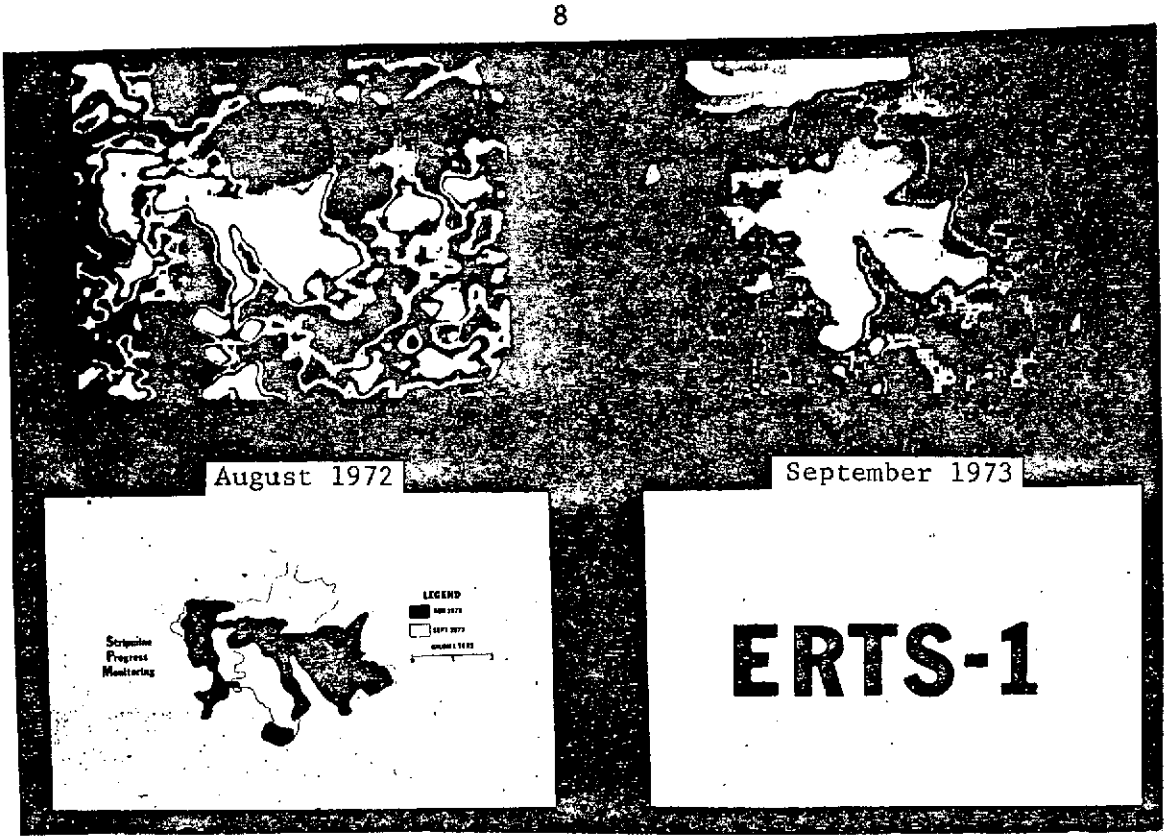


FIGURE 4. USE OF MULTIDATE ERTS-1 DATA TO MONITOR OHIO STRIP MINING ACTIVITIES

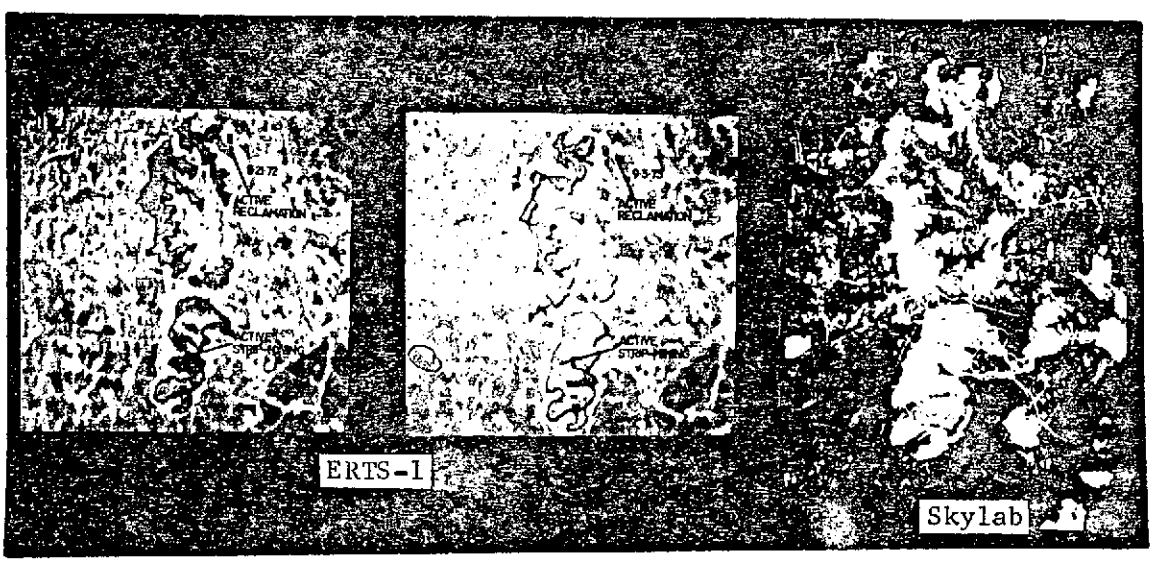


FIGURE 5. COMPARISON OF MULTIDATE ERTS-1 AND SKYLAB IMAGERY FOR DETECTING STRIP MINING PROGRESS AND RECLAMATION CHANGES

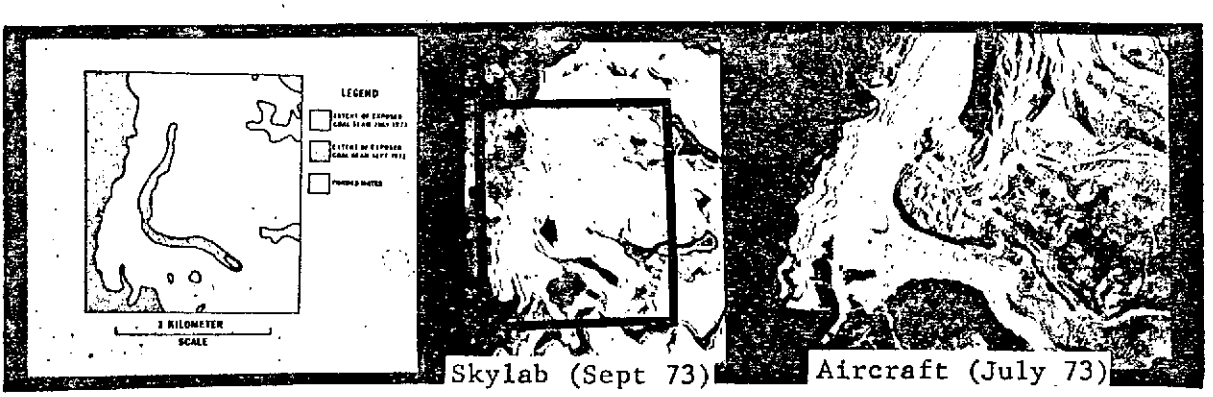


FIGURE 6. COMPARISON OF AIRCRAFT AND ENHANCEMENT OF SKYLAB PHOTO SHOWN IN FIGURE 5 TO REVEAL EXTENT OF COAL EXCAVATION IN A TWO-MONTH PERIOD

2.2.2 LAND USE

Improvement in national land use practices will require more knowlegeable and coordinated decision making of land use-related problems such as unplanned growth, land misuse, and deteriorating environmental quality at the state level. Ohio, like every other state, has increasing multiagency requirements for periodic and relatively inexpensive inventories of the state's land and natural resources for use in general planning, land-use decision making, and legislation preparation. Accordingly, a high-priority State interest exists relative to the extent, accuracy, and cost of using satellite data to periodically update such land-use information.

Program efforts to date have demonstrated the types of imagery and digital satellite survey data analysis techniques and products that can be produced on a routine basis for solving land-use problems, for general land use planning, and for meeting the longer range requirements of the pending National Land Use Policy Act.(7) Preliminary evaluation of the usable orbital survey imagery existing for Ohio, indicates that the data are more than adequate for periodically mapping and inventorying major surface natural and cultural features at scales of 1:24,000 and smaller and at less cost and with better accuracies than with previous techniques. The extent to which various Ohio land use features have been discerned on ERTS and Skylab data relative to the land use classification system proposed by the U. S. Geological Suvery for use with remotely sensed data is provided in Table II (8). Demonstrations of orbital survey data to land use applications at scales comparable to state, regional and local jurisdications in Ohio have been included in several reports(1-3,7) and are only briefly summarized below.

Several black and white mosaics of the entire State of Ohio from ERTS MSS Band 5 images and a color-composite mosaic (scale 1:250,000) have been assembled by the Department of Transportation and the Department of Economic and Community Development(3,7). The significance of the mosaics is that, for the first time, a current, comprehensive, synoptic view of Ohio's many diverse environmental, natural, and cultural surface features and their interrelationships is available for general planning purposes. A statewide inventory of the land uses in Ohio was the objective of a 1960 Ohio land use study which produced tabulated land use data and generalized 1:250,000-scale land use maps and a 1:500,000-scale land use map. This Ohio land use study was completed in 1968 utilizing 1940-1960 data. Although the tabulated land use data provided a much needed detailed land use information base, the study and, particularly, the maps have been found to be inaccurate in numerous areas. However, there are some critical tradeoffs involved by utilizing synoptic orbital surveys rather than data obtained by conventional methods. For example, the 1960 study was done at a scale of 1:24,000 and then combined and generalized to arrive at the 1:250,000 and 1:500,000 maps. Thus, detailed land use work sheets were available both as backups and for use by planners requiring detailed information. Using satellite imagery, this won't be possible except for cases wherein detailed land use maps are made for selected areas of the state.

A high resolution (H.R.) Color Skylab S 190 B photograph of 9 August 73 of northeastern Ohio was used to produce USGS Level I and Level II

TABLE II. OHIO LAND USE FEATURES DISCERNIBLE ON ERTS AND SKYLAB IMAGERY.

USGS Land Use Classification System for Use With Remote Sensor Data*(8)			Analysis Status	
			ERTS	Skylab
Level I	Level II			
01. Urban and Built-up Land				
	01.	Residential	No	Yes
	02.	Commercial and Services	No	Yes
	03.	Industrial	No	Yes
	04.	Extractive	Yes	Yes
	05.	Transportation, Communications, and Utilities	Yes	Yes
	06.	Institutional	No	Yes
	07.	Strip and Clustered Settlement	Yes	Yes
	08.	Mixed	Yes	Yes
	09.	Open and Other	Yes	Yes
02. Agricultural Land				
	01.	Cropland and Pasture	Yes	Yes
	02.	Orchards, Groves, Bush Fruits, Vineyards, and Horticultural Areas	No	TBD*
	03.	Feeding Operations	No	TBD
	04.	Other		
03. Rangeland				
	01.	Grass	N/A**	N/A
	02.	Savannas (Palmetto Prairies)	N/A	N/A
	03.	Chaparral	N/A	N/A
	04.	Desert Shrub	N/A	N/A
04. Forest Land				
	01.	Deciduous	No	TBD
	02.	Evergreen (Coniferous and Other)	No	TBD
	03.	Mixed	Yes	Yes
05. Water				
	01.	Streams and Waterways	Yes	Yes
	02.	Lakes	Yes	Yes
	03.	Reservoirs	Yes	Yes
	04.	Bays and Estuaries	Yes	Yes
	05.	Other (Ice and Snow)	Yes	Yes
06. Nonforested Wetland				
	01.	Vegetated	Yes	Yes
	02.	Bare	Yes	Yes
07. Barren Land				
	01.	Salt Flats	N/A	N/A
	02.	Beaches	No	Yes
	03.	Sand Other Than Beaches	N/A	N/A
	04.	Bare Exposed Rock	No	TBD
	05.	Other		
08. Tundra				
	01.	Tundra	N/A	N/A
09. Permanent Snow and Icefields				
	01.	Permanent Snow and Icefields	N/A	N/A

* TBD = To be determined by future analysis.

** N/A = Classification not applicable to Ohio.

land use classification maps for the Cleveland/Cuyahoga County area shown in Figure 7. Using standard planimetric techniques, areas of each of the 10 land use categories were calculated. Correlative analyses using aircraft underflight data are currently in progress. Upon further enlargements to scales of 1:90,000 and 1:24,000 additional detail extraction and feature classification are possible as seen in Figures 8-9. At the same local/neighborhood scale, the feasibility of using ERTS-1 data to discern land use changes and update land use maps in both computer and photographic formats has been illustrated(3,7). At the 1:24,000 scale, ERTS-1 data were compared with aircraft and USGS topographic map data of a subdivision in the norhteastern sector of the Columbus metropolitan area. This comparison clearly illustrated the degree of feature detail and change that may be extracted from ERTS data through magnification and electronic enhancement of imagery and computerized multiband processing.

In addition to detecting, inventorying, mapping, and monitoring natural and cultural surface features at state, regional, and local scales, ERTS and Skylab data can also be used in planning and monitoring specialized developments and activities such as nuclear power facilities; transportation facilities; reservoirs, parks, and recreational facilities; prime agriculture lands and areas of environmental concern; urban growth and development; and extractive industries such as surface mining. Sample illustrations of these applications are contained in reference (7).

2.2.3 RESOURCE MANAGEMENT

The Ohio Biological Survey currently is conducting an Environmental Analysis of Central Ohio for the Huntington District, U. S. Army Corps of Engineers. The prime objective of the study is to inventory and evaluate from existing data the environmentally valuable physical, biological and cultural resources of the Central Ohio Water Development Region. This region is nearly 28,500 km^2 in extent, or about 27 percent of Ohio. A major problem confronted early in the study was the need to procure a general and inexpensive yet accurate map distinguishing the wooded and non-wooded areas over this large region. Topographic maps and aerial photography available and indicating wooded areas for the region were too dated, incomplete, and/or too detailed to be condensed and incorporated with available time and funds. Utilization of ERTS-1 MSS Band 5 imagery through density analysis to prepare transparency overlays of the wooded area within the entire Water Development Region proved to be an ideal solution to the problem. Figure 10 shows one of the thematic transparencies superimposed over existing 1:250,000 USGS topographic map sheets. Although the transparency clearly illustrates the significant changes that have occurred in southeastern Ohio's forestry resources since 1968 (when compared to 1:250,000 topographic map) the importance lies in the generation of a new ERTS data product type potentially useful for providing dynamic statewide views of natural and cultural features in single and/or combined formats. For selected study-site areas, the transparency is over 95 percent accurate for mature forested areas in excess of 10 hectares (25 acres), and although the accuracy has not as yet been determined for extrapolated regions, it appears comparable to the USGS 1:24,000 maps and more accurate than the 1:250,000, especially for urbanized areas.

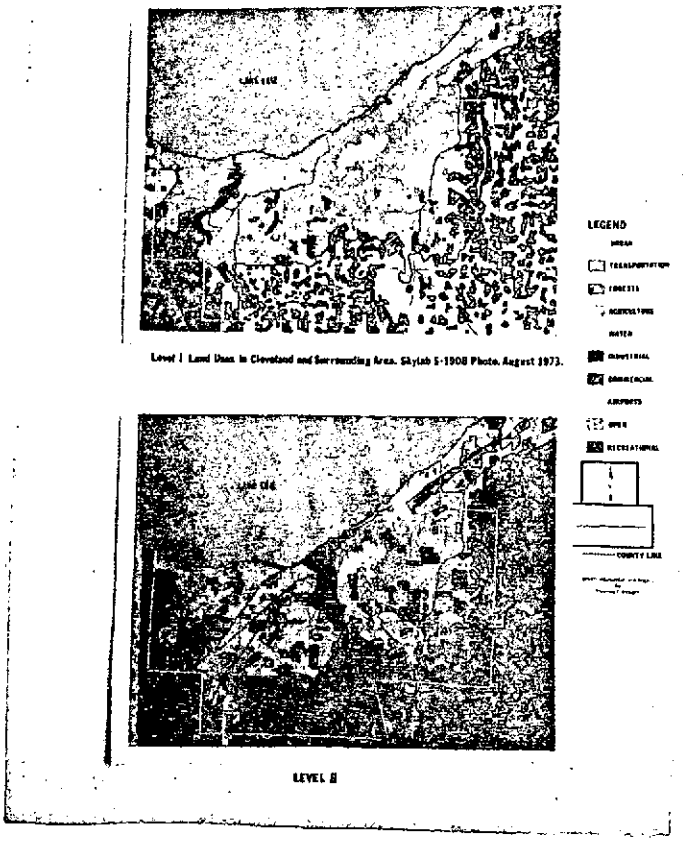


FIGURE 7. LAND USE CLASSIFICATION FOR CLEVELAND/CUYAHOGA COUNTY, OHIO FROM SKYLAB S 190 B IMAGERY

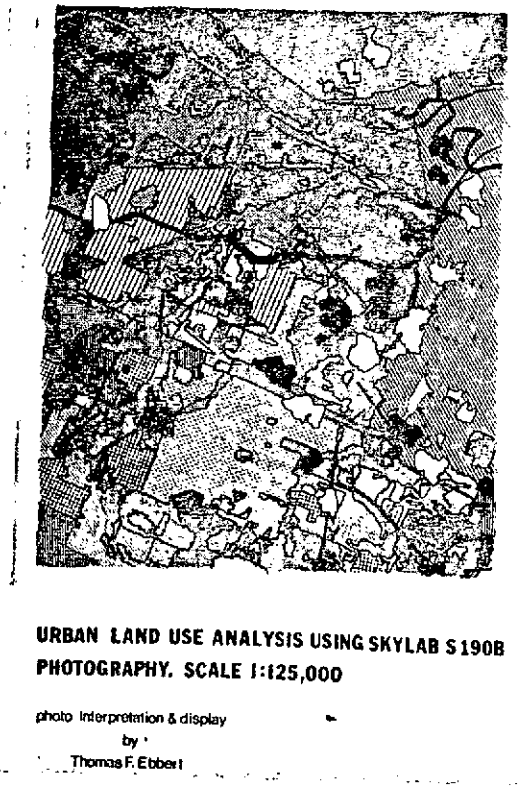


FIGURE 8. CLEVELAND LAND USE ANALYSIS FROM SKYLAB S 190 B IMAGERY (Scale 1:125,000)

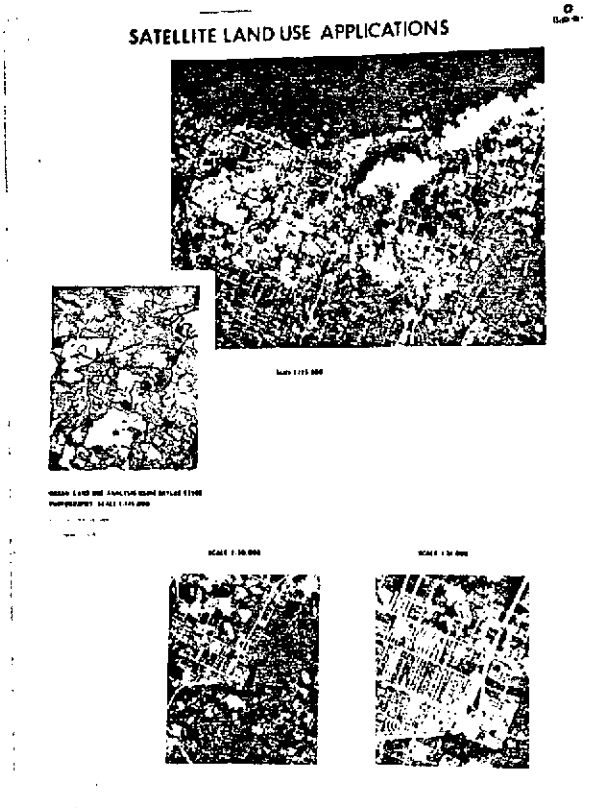


FIGURE 9. URBAN LAND USE PATTERNS ON ENLARGED SKYLAB PHOTOGRAPHY

(Scales 1:90,000-1:24,000)

FIGURE 10. ERTS-1 THEMATIC OVERLAY OF FORESTED AREAS IN SOUTHERN OHIO

(Orig. Scale 1:250,000)

In response to the provisions of pending federal land use legislation, the voter passage of Issue I in Ohio which permits lower agricultural property assessments, and other various pressures that indicate a need to formulate a state land use program, the Department of Economic and Community Development has recently initiated an in-depth study to include historical research, policy formulation, and data collection activities relative to designating prime or unique agricultural land in Ohio. In this prime agricultural land study, it is anticipated that EREP data (supplemented by ERTS data) will be used to aid in formulating operational criteria for designating prime agricultural land, in determining the location of such lands in Ohio, and in the assessing of the interrelationship of prime agricultural lands to environmental, economic, a and social parameters such as open space, market distribution centers, and urban sprawl. Figure 11 provides an black and white illustration of natural and cultural features discernible on a S 190 B, IR scene of Eastern Ohio of 15 Sept 73.

3. USER AWARENESS AND UTILITY ASSESSMENT

The Ohio ERTS and Skylab programs have concentrated on that end-user familarization with multispectral data from both aircraft and satellites, and with earth resources survey discipline developments in general, so that the experimentally demonstrated user application opportunities will become operational realities and additional application possibilities identified. Accordingly, the major user awareness technique employed involved laboratory demonstrations of what ERTS and Skylab data reveal in magnified, color-composite and enhanced, multidate, and digitized formats. To date, over 1,000 visitors have toured the laboratory established at Battelle's Columbus for analyzing ERTS and Skylab imagery. Many of the visitors represent working level planners and decision makers from the various participating state agencies, many of which have made repeated visits during which State and Battelle personnel have jointly analyzed ERTS and Skylab data in regard to a variety of State data requirements. Other visitors have included students, regional planners, and interested representatives of other states and nations.

In March 1974, the Ohio Department of Economic and Community Development in conjunction with Battelle Columbus Laboratories sponsored a Ohio ERTS/Skylab Data User Workshop in which approximately 100 land use, resource, and environmental planners from all sections and levels of government and private sector participated. While serving basically as another user awareness activity, the workshop was also tailored to solicit user views as to the potential usefulness and/or limitations of data and data products obtainable from satellite surveys.

The Ohio satellite survey program has also contributed to efforts to pursue the educational implications of this new technology. Close cooperation is maintained with the Committee on Remote Sensing at The Ohio State University which is providing academic leadership in this area. This Committee has
1) successfully presented a five-day Remote Sensing Short Course in 1972,
2) initiated an Interdepartmental Seminar on Remote Sensing in 1973, and
3) made plans for establishing a formal undergraduate degree program in remote sensing as well as offering a second short course this summer emphasizing remote sensing data applications.

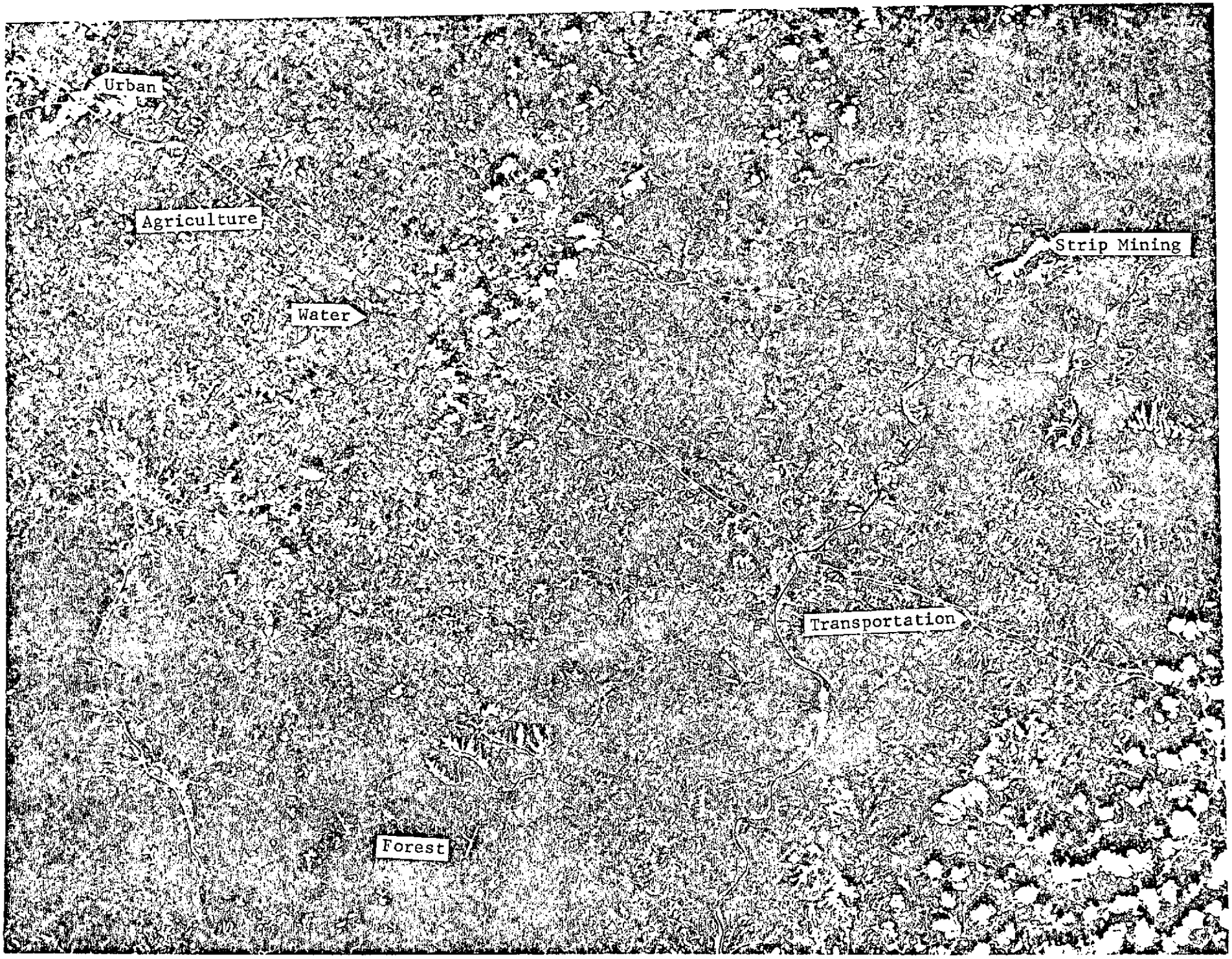


FIGURE 11. OHIO NATURAL AND CULTURAL FEATURES DISCERNIBLE ON SKYLAB S 190 B IMAGERY

State assessment of the utility/relevance of ERTS and Skylab data is being based on a combination of 1) user attitudes expressed while directly participating in laboratory problem-solving exercises, 2) user evaluation of application-oriented ERTS and Skylab demonstration products generated during the course of the program, and 3) user views expressed directly or recorded on questionnaires during the Ohio ERTS and Skylab Data User Workshop.

In general, the overall user response in Ohio is one of much enthusiasm as to the potential of these data, but in no case is routine/operational use being made. Some investments have already been made in selected application categories by the Department of Natural Resources, the Department of Community Development and Battelle's Columbus Laboratories but nothing approaching an operational use. Based upon an integration of user experiences to date, preliminary recommendations are provided in Table III as to the spectral, spatial, and temporal capabilities required to be of maximum operational benefit to the various on-going State functions. Most data demands are within present ERTS and Skylab capabilities.

In summary, two major points merit comment concerning user awareness and data utility. Of the hundreds of potential state and local users who have been exposed to these data, the response has been extremely enthusiastic. Those areas where the data have not shown utility appear to require more frequent coverage, greater spatial resolutions, and/or additional sensors (i.e., thermal, microwave, etc.). More important, however, user awareness in Ohio has progressed to a point where, although additional efforts must be expended from user awareness and utility assessments to maintain contact with the many potential users, a shift in emphasis from user awareness and utility assessments to development of operational satellite data user systems must be made. This will be an extremely difficult task for Ohio or any single unit of government to accomplish without resource assistance from the federal level.

TABLE III. PRELIMINARY RECOMMENDATIONS FOR OPERATIONAL SATELLITE EARTH RESOURCES SURVEY DATA REQUIREMENTS

(Environmental Quality, Land Use, and Resource Management Applications Only)

State Functions	Product Types	Data Requirements				
			Spatial Resolution(in Meters)			
		Spectral Range	State	Regional	Local	Temporal Range
Research/Education/Communications	Maps, photographic and digital displays, and models	Multispectral (all bands visible to microwave)	80	80	80	Periodic 18 days
Planning (Data Collection and Analysis)	Maps, photographic and digital displays, and models	Multispectral (visible to thermal IR 4 to 7 bands)	<80	30	10	Seasonal to daily
Management/Decision Making	Output from planners	Multispectral (visible to thermal IR)	30	10	10	Seasonal to daily
Policy Formulation/Legislation	Output from Managers-Dept. Directors	Multispectral (visible to thermal IR)	30	10	10	Yearly
Enforcement (Surveillance/ Monitoring)	Computerized to detect changes	Multispectral (visible - thermal - microwave plus DCS/DCP)	10	10	10	18 days automatically to daily on demand

4. REFERENCES

1. David C. Sweet, Terry L. Wells, George E. Wukelic, "Resource Management Implications of ERTS-1 to Ohio," Symposium on Significant Results Obtained From the Earth Resources Technology Satellite-1, GSFC, New Carrollton, Maryland, March 1973, Vol I, Section B, pp 1459-1466.

2. D. C. Sweet, et al., "Applications of Remote Sensing to Resource Management at the State Level." Symposium on Management and Utilization of Remote Sensing Data, American Society of Photogrammetry, Sioux Falls, South Dakota, October 29-November 2, 1973.

3. D. C. Sweet, G. E. Wukelic, J. G. Stephan, and H. E. Smail, "Significant Applications of ERTS-1 Data to Resource Management Activities at the State Level in Ohio", Third NASA ERTS Symposium, Washington, D. C., December, 1973.

4. W. A. Pettyjohn, R. H. Rogers, and L. E. Reed, "Automated Strip-Mine and Reclamation Mapping From ERTS", Third NASA ERTS Symposium, Washington, D. C., December, 1973, 13 pages.

5. "Land Reborn", Board of Unreclaimed Strip Mined Lands and Department of Natural Resources, State of Ohio, January, 1974, 90 pages.

6. G. E. Wukelic, J. G. Stephan, and T. F. Ebbert, "Demonstration of the Application of Satellite Survey Data: Surface Mining", Battelle, Columbus Laboratories, July 15, 1973, 17 pages.

7. G. E. Wukelic, J. G. Stephan, H. E. Smail, and T. F. Ebbert, "Demonstration of the Application of Satellite Survey Data: Land Use", Battelle, Columbus Laboratories, January, 1974, 18 pages.

8. J. R. Anderson, E. E. Hardy, and J. T. Roach, "A Land Use Classification System for Use With Remote Sensor Data", U. S. Geological Survey Circular 671, Washington, D. C., 1972.